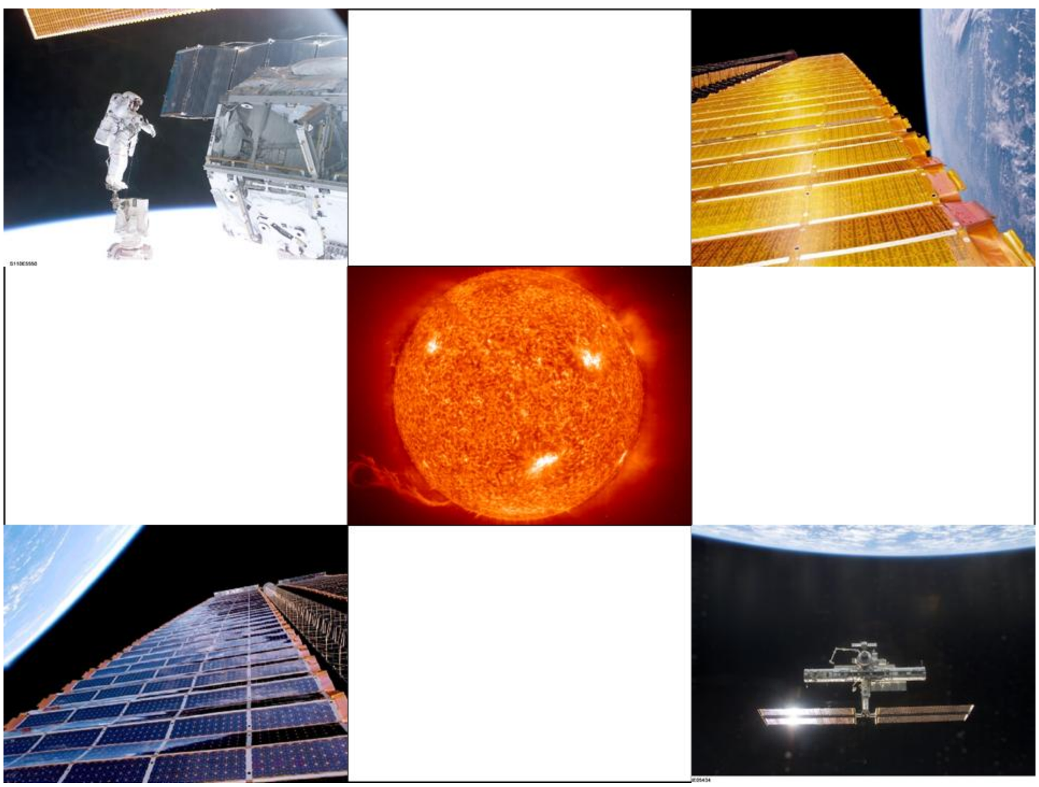
National Aeronautics and Space Administration

Solar Energy:
It’s Importance to Earth and Space Exploration
A Digital Learning Network Experience

Designed To Share



The Vision for Space Exploration

Solar Energy: Its Importance to Earth and Space Exploration

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Digital Learning Network (DLN) Expedition

A DLN Expedition is a one time connection that allows students to experience NASA first-hand. Each expedition features an integrated educational package of grade-appropriate instruction and activities centered on a 50 minute videoconference. Students participate in a Question and Answer session with a NASA JSC education specialist or a NASA Subject Matter Expert.

The sequence for a DLN Expedition includes:

- Students complete vocabulary and Pre-Classroom Activity
- A one time DLN videoconference connection with in-formal student participation.
- Complete Post-Activity Assessment and complete online evaluation for teacher and students.

Expedition Overview

Grade Level **5-8**

Focus Question
What impact does solar energy have in space and on Earth?

Instructional Objectives
Students will understand the importance of energy.
Students will discuss the historical foundations of energy and its production.
Students will understand the two types, kinetic and potential energy, and the two forms, particle and wave.
Students will understand how NASA utilizes the sun and solar cells to run missions.
Students will understand future uses for energy in space travel and here on Earth.
Students will identify careers associated with energy studies.

National Standards
National Science Education Standards (NSES)
- Science as Inquiry – Content Standard A
- Physical Science – Content Standard B
- Life Science – Content Standard C
- Earth and Space Science – Content Standard D
- Science and Technology – Content Standard E
- Science in Personal and Social Perspectives – Content Standard F
- History and Nature of Science – Content Standard G

National Council of Teachers of Mathematics (NCTM)
- Measurement - Standards 12C, 13B

International Technology Education Association (ITEA)
- Energy and Power Techniques – Standard 16A

Texas State Standards
5.8 Science Concepts – Standard B
6.9 Science Concepts – Standard B
8.2 Science Processes – Standards A, C

Sequence of Events

<u>Pre-Conference Requirements</u>

Online Pre-assessment A pre-assessment tool is available to determine the students' level of understanding prior to the videoconference. Suggested answers are included.

<u>Expedition Videoconference</u>

Expedition Videoconference (About 45-60 minute conference)
Travel through time as we see how solar energy was used in the past, how it is used today, and how it could be used in the future. Learn about the various forms of energy and how it is being used at NASA for missions in space. See first hand how solar cells work and how they are used to power the ISS and the rovers on Mars.

<u>Post-Conference Requirements</u>

Online Post-assessment
A post-assessment tool is available to determine changes in student levels of understanding.

<u>NASA Education Evaluation Information System (NEEIS) Feedback Forms</u>

Educator and student feedback forms are available online for all DLN events.

<u>Post-Conference Requirements</u>

Online Post-assessment
A post-assessment tool is available to determine changes in student levels of understanding.

<u>NASA Education Evaluation Information System (NEEIS) Feedback Forms</u>

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National Standards

National Science Education Standards (NSES)

National Education Standards *Science*	Potential or Kinetic?	Angles and Electricity	Chain Reaction
Content Standard A: Science as Inquiry			
Abilities Necessary to do Scientific Inquiry	X	X	X
Understanding About Scientific Inquiry	X	X	X
Content Standard B: Physical Science			
(K-4) Position and Motion of Objects	X		
(5-8) Transfer of Energy		X	
(9-12) Chemical Reactions			X
(9-12) Conservation of Energy and Increase in Disorder			X
Content Standard C: Life Science			
Regulation and Behavior			
Content D: Earth and Space Science			
Earth in the Solar System			
Content Standard E: Science and Technology			
Abilities of Technological Design	X	X	X
Understandings About Science and Technology	X	X	X
Content Standard F: Science in Personal and Social Perspectives			
Natural Hazards			
Risks and Benefits			
Content Standard G: History and Nature of Science			
Science as a Human Endeavor			

National Council of Teachers of Mathematics

National Council of Teachers of Mathematics ***Mathematics***	**Potential or Kinetic?**	**Angles and Electricity**	**Chain Reaction**
Measurement			
12C: Understand, select, and use units of appropriate size and type to measure angles, perimeter, area, surface area, and volume		X	
13B: Select and apply techniques and tools to accurately find length, are, volume, and angle measures to appropriate levels of precision		X	

International Technology Education Association

International Technology Education Association ***Technology***	**Potential or Kinetic?**	**Angles and Electricity**	**Chain Reaction**
Energy and Power Techniques			
16A: Energy comes in many forms	X		

Texas Essential Knowledge and Skills

Texas Essential Knowledge and Skills

Texas Science Essential Knowledge and Skills TAKS Objectives *Science*	**Potential or Kinetic?**	**Angles and Electricity**	**Chain Reaction**
Objective 1: The student will demonstrate an			
understanding of the nature of science			
Scientific processes	X	X	X
Objective 2: The student will demonstrate an			
understanding of the life sciences			
Scientific concepts	X	X	X
Objective 3: the student will demonstrate an			
understanding of the physical sciences			
Scientific concepts: the student knows that complex interactions occur between matter and energy	X	X	X
Scientific concepts: the student knows that energy comes in many different forms	X	X	X
Objective 4: The students will demonstrate an			
understanding of the earth sciences			
Scientific concepts	X	X	X

Pre-Conference Requirements

Pre-Assessment

A week before the event, students will need to take the pre-conference assessment. This short assessment will provide useful background information for the presenters to prepare for the videoconference.

Pre-Conference Assessment Questions

1. **What is energy?**
2. **Who is Sir Isaac Newton?**
3. **Where do we get solar energy?**
4. **What are the two types of energy?**
5. **How is light related to energy from the sun?**
6. **How do angles influence solar energy collection?**
7. **What is a photovoltaic cell?**
8. **Why would the study of solar energy be important to NASA?**
9. **How is solar energy used on Earth?**
10. **What kind of job could you have at NASA that relates to energy?**

Pre-Conference Requirements

Teacher's Page with suggested answers:
Answers to Pre and Post Assessment Questions

1. **What is energy?** Energy is the strength or power to work or be active; force; vigor; the power of certain forces of nature to do work.

2. Who is Sir Isaac Newton? Scientist who was the first to argue that light energy was not waves but particles.

3. Where do we get solar energy? The sun provides the energy but we need a means to harness and direct that energy.

4. What are the two types of energy? Kinetic and potential

5. How is light related to energy from the sun? Light is absorbed by solar cells which convert it to electricity for us to use.

6. How do angles influence solar energy collection? The better the angle, the more efficiently we can collect solar energy. For example, solar cells collect the maximum amount of energy when directly facing the sun. Thus depending on the orientation can be different at different times of the year here on Earth.

7. What is a photovoltaic cell? Cell capable of producing a voltage when exposed to radiant energy, especially light

8. Why would the study of solar energy be important to NASA? It provides a means for us to power the ISS, our rovers on Mars, and possibly future missions to space and even benefits for us here on Earth.

9. How is solar energy used on Earth? As renewable energy to power homes, cars, and buildings. Future uses are endless as technology advances.

10. What kind of job could you have at NASA that relates to energy? A variety of areas ranging from engineering, communications, to technology.

Expedition Videoconference Guidelines

Audience Guidelines

Teachers, please review the following points with your students prior to the event:

- Videoconference is a two-way event. Students and NASA presenters can see and hear one another.
- Students are sometimes initially shy about responding to questions during a distance learning session. Explain to the students that this is an interactive medium and we encourage questions.
- Students should speak in a loud, clear voice. If a microphone is placed in a central location instruct the students to walk up and speak into the microphone.
- Teacher(s) should moderate students' questions and answers.

Teacher Event Checklist

Date Completed	Pre-Conference Requirements
	1. Print a copy of the module.
	2. Have the students complete the pre-assessment.
	3. Email questions for the presenter. This will help focus the presentation on the groups' specific needs.
	4. Review the Audience Guidelines, which can be found in the previous section.
	Day of the Conference Requirements
	1. The students are encouraged to ask the NASA presenter qualifying questions about the Expedition.
	2. Follow up questions can be continued after the conference through e-mail.
	Post - Conference Requirements
	1. Have the students take the Post-Assessment to demonstrate their knowledge of the subject.
	2. Use the provided rubric as guidelines for content and presentation criteria.
	3. Teacher(s) and students fill out the event feedback.

Expedition Videoconference Outline

Introduction to Expedition Videoconference

Travel through time as we see how solar energy was used in the past, how it is used today, and how it could be used in the future. Learn about the various forms of energy and how it is being used at NASA for missions in space. See first hand how solar cells work and how they are used to power the ISS and the rovers on Mars.

Outline for Video Conference

- **I. Welcome**
- **II. Introduction**
- **III. Historical Foundations of Energy**
  - **a. Ancient Civilizations**
  - **b. Scientific Revolution**
  - **c. Modern Age**
- **IV. Understanding Forms of Energy**
  - **a. Potential**
  - **b. Kinetic**
- **V. Solar Energy and Light Spectrum**
  - **a. Electromagnetic spectrum**
  - **b. Prism demonstration**
- **VI. NASA Energy Aboard ISS**
  - **a. Solar Cells Demonstration**
- **VII. Future Uses of Energy**
- **VIII. Careers/Website**
- **IX. Q&A**
- **X. Good-Bye**

Pre-Classroom Activities

Activity: Angles and Electricity

Article: Beaming Down Energy

Here's a current events quiz: Why is the cost of energy— electricity, gasoline, and natural gas— increasing so rapidly? Can we anticipate any relief? What's NASA doing to help the problem?

The United States Congress has asked NASA to explore inexpensive and efficient answers concerning energy conservation, and the big answer appears to be solar energy. Don't we already know all about solar energy? Aren't there already solar collection panels scattered across the country? Would it be reasonable to say that solar energy isn't a major factor in the consumer energy business? The answer to all three questions is yes, but don't let that stop you. The solar energy NASA is exploring isn't anything like the solar energy you may be thinking of.

Space Solar Power (SSP) involves collecting solar energy in space from a constellation of solar power satellites, converting it to electricity, and beaming it down to Earth instead of using solar collectors on Earth. SSP addresses several key concerns, has generated various concepts for different levels of power demands, has achieved many technological innovations over conventional solar energy plans, and it and proposes promising solutions.

Earth-based Solar Energy Is Inefficient

Collecting solar energy on Earth is inefficient. Less than 50 percent of the Sun's energy can be used to create electricity for us on Earth. Scientists at several NASA centers have attacked this problem and found ways to make solar power more energy efficient.

Because most energy is currently obtained from the blue part of the light spectrum, scientists have built large prisms to separate bands of the light spectrum, so they can "harvest" energy from the various wavelengths that constitute white light.

Scientists also know that solar energy reaching the Earth is dependant on atmospheric conditions. If the weather is cloudy or stormy, not nearly as much solar energy will be able to make its way down to solar collection panels on Earth. Customers purchasing electricity want reliable, consistent power.

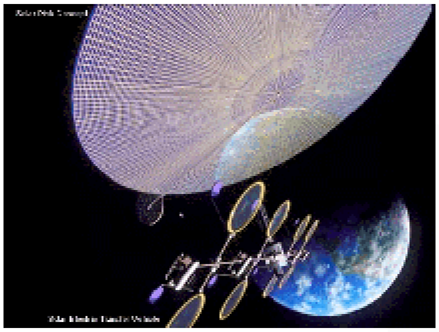
If the solar collection devices are moved from rooftops to satellites stationed above the clouds over Earth, the atmospheric variable is eliminated, so unobstructed solar energy can be collected. Concentrators can focus the sun's energy on photovoltaic arrays hovering just above the Earth. The energy can be converted to microwave or laser beams and sent back to Earth. Just as cell phones and television satellite dishes receive their signals directly from space, solar energy consumers— whether they're powering a hybrid electric-gas automobile engine or a house's electric-gas utilities— can access the power 24 hours a day. They'd contract the energy services through a service provider who installs the hookups- just like cell phones and satellite dishes.

With the combination of high-density concentrators, thin film prisms, and innovative multi-band gap photovoltaic concepts, 44 percent of the Sun's energy can be converted to electricity. The remaining energy remains as heat. Using recent breakthroughs in thermo-photovoltaic study, 15 percent of the heat can be converted to energy. That removes heat from the photovoltaic array. Scientists expect that solar satellites could extract close to 65 percent of the Sun's energy in the foreseeable future.

Earth-Based Solar Energy is Expensive

Solar energy is fairly expensive, because the solar arrays and collectors are so costly to produce and install. A photovoltaic cell costs approximately $200 per square inch, for example. In 2000, solar energy cost approximately $0.80 to $1.00 per kilowatt-hour, compared to $0.06 for coal, natural gas or high sulphur gas. There was little incentive for customers or industry to switch to solar power.

More recently, energy prices have skyrocketed. "There are taxes levied on sources of environmental pollution, and those taxes are passed along in higher prices," says Dr. Neville Marzwell, technical manager of the Advanced Concepts and Technology Innovations program at NASA's Jet Propulsion Laboratory in California. "Additionally, many power plants are aging and need to be replaced. The cost of building or remodeling these structures also is passed along to the consumer. Nuclear power plants are being de-commissioned. The combination of increased operating expenses and increased demand means that energy is going to cost more. In California, for instance, electricity now costs between 60 and 80 cents per kilowatt-hour.



Marzwell feels that the cure for the problem is creating a good economical base so that solar energy is every bit as efficient and economical— maybe more so— than conventional energy sources. The magic is in creating high-efficiency solar collection devices. That's what the Space Solar Power project is all about.

Congress has commissioned NASA to create a program to focus concentration on producing clean, economical energy for our country. Once America's energy needs are under control, additional energy could be exported to the rest of the world as a source of revenue.

"Besides helping our energy needs on Earth, SSP can also work to re-fuel other satellites that currently have to be replaced because they're out of power. Communication and military satellites have a short life that could be greatly extended if we can get more energy to them. That would be another way SSP could be economical."

Depending on how supportive Congress is of SSP, the project could be fully functioning by 2020 to 2040, Marzwell says. "The Sun's energy is free, not like gas and oil, which are becoming scarce," he says. "The expense comes from the process of obtaining it. Our goal is to make that process both efficient and inexpensive, while producing nonpolluting energy."

Adapted from NASA's Space Operations Mission Directorate

Information in this article was accurate as of the publication date. For the latest updates about this project, visit the NASA homepage (http://www.NASA.gov).

Angles and Electricity

Teacher Sheet(s)

Objective:	To measure the energy output of a photovoltaic cell under varying conditions.
Level:	5-8
Subjects(s):	Science, Mathematics
Prep Time:	Less than 10 minutes
Duration:	One class period
Materials Category:	Special Requirements

National Standards:

Science:	3c
Math:	12c, 13b
Technology (ISTE):	
Technology (ITEA):	

Materials:

- Photovoltaic (PV) cell
- DC meter
- Protractor

Related Links:
Site used for derivation of Lesson Plan
Solar Matters - Florida Solar Energy Center

Supporting Article:
Beaming Down Energy

Pre-Lesson Instruction: *(none)*

Background Information: *(none)*

Guidelines:

1. Read the article, "Beaming Down Energy."
2. Divide into teams of two to three students.
3. Provide each student with 1 photovoltaic cell, 1 DC meter, protractor, and reflectors.
4. Attach alligator clamps on the panel to the wires on the DC meter.
5. Connect the red clamp on the PV cell to the red clamp on the meter. Connect the black clamp on the PV cell to the black clamp on the meter.
6. Place PV cell in sunlight, read meter, and record reading.
7. Move PV cell to various angles, read meter, record.
8. Test cell at 0 degrees, 45 degrees, 90 degrees, and so on.

Discussion/Wrap-up:

- Did your results cause you to think of more questions to explore?
- How does this represent some of the problems with collecting solar energy on the Earth as opposed to collecting with a satellite?

Extensions:

- Repeat test at different times of the day and the year.
- Try this experimenting while simulating cloud coverage, or do the activity on a cloudy day.

Angles and Electricity

Student Sheet(s)

Materials:

- Photovoltaic (PV) cell
- DC meter
- Protractor

Procedure:

1. Attach the meter to the PV cell.
2. Using the ground as a baseline, tilt the PV cell toward the sun.
3. Observe the needle on the meter.
4. Measure at least 5 different angles using the protractor.
5. Record your results.

Angle	Meter Reading

Record time of day: ______________________

Post-Conference

Online Post-Assessment

After the event students will need to take the post-conference assessment. (These questions are the same questions used in the pre-assessment.) The short assessment will help us measure student learning and identify any changes that need to be made in future programs.

Post-Conference Assessment Questions

Grades 5-8

1. **How do angles influence solar energy collection?**

2. **How does a photovoltaic cell work?**

3. **Is collection of solar energy from space more efficient than on Earth? Why?**

NASA Education Evaluation Information System (NEEIS)

Please complete an online evaluation form to provide feedback on the NASA Challenge.
Feedback from you and a few of your students would be appreciated.

http://dln.nasa.gov/dln/content/feedback/

National Aeronautics and Space Administration

NASA Digital Learning Network

presents

Certificate of Completion

to

____

for

Completing the Solar Energy: Transfer to Conservation Expedition

_______________________ *Instructor*

_______________________ *Date*

Vocabulary

Guidance: any of various processes for guiding the path of a vehicle, especially a missile, by means of built-in equipment

Navigation: the guidance of ships or aircraft from place to place

Gyroscope: a device consisting of a spinning mass, typically a disk or wheel, mounted on a base so that its axis can turn freely in one or more directions and maintain its orientation regardless of any movement of the base

Attitude: the position of an aircraft or spacecraft determined by the relationship between its axes and a reference datum (as the horizon or a particular star) ; Of an aircraft in flight, the angle made be its axes with the relative airflow

Arrays: order; a regular and imposing arrangement

Masts: a pole that extends outward and holds the solar panels on the International Space Station; a vertical pole that extends from a ship to support its sails

Solar Energy: usable power derived from the Sun

Light Spectrum: a band of color formed when a beam of white light is spread (as by passage through a prism) so that its different wavelengths are arranged in order

Atmospheric: of, relating to, or occurring in the atmosphere

Photovoltaic: capable of producing a voltage when exposed to radiant energy, especially light

Energy: strength or power to work or be active; force; vigor; the power of certain forces of nature to do work

Heat Transfer: The transfer or exchange of heat by radiation, conduction, or convection within a substance and between the substance and its surroundings.

Wavelength: a measure of a light; the peak – to peak distance one vibration of an electromagnetic wave

Solar Cell: a type of generator that produces electricity whenever sunlight shines on it

Kinetic Energy: The energy that an object has by virtue of its motion.

Potential Energy: The energy that an object has by virtue of its position in a field.

Battery: a cell or connected group of cells that converts chemical energy into electrical energy by reversible chemical reactions and that may be recharged by passing a current through it in the direction opposite to that of its discharge—called also storage cell

Power: The rate at which work is done or energy is released.

Nuclear: Of or relating to atomic nuclei

Fission: the splitting of an atomic nucleus resulting in the release of large amounts of energy

Fusion: the joining together of atomic nuclei to form heavier nuclei resulting in the release of enormous quantities of energy

Atom: one of the tiny particles of which all things are made

Nucleus: The small concentration of protons and neutrons, positively charged, at the center of atoms. The nuclei of atoms are positively charged and contain by far most of their mass (all but about 0.05% or less). The existence of the nucleus was deduced in 1911 by Ernest Rutherford, from experiments on the scattering of alpha particles by nuclei.

Neutron: A particle found in the nuclei of atoms, similar to a proton but with no electric charge. Among light nuclei (helium, carbon, nitrogen), the ones that are most stable contain equal numbers of protons and neutrons. In heavier elements, the most stable ones have majority of neutrons, growing with mass. Varieties of nuclei also exist ("isotopes") which have other ratios between their numbers of protons and neutrons, but when the departure from the "most stable ratio" becomes large, neutrons can convert to protons + electrons (or vice versa), producing one form of radioactivity.

Chain Reaction: A reaction in which some of the products initiate further reactions of the same kind allowing the reaction to become self-sustaining.

Solar Energy Word Scramble
Grades 6-12

Name ______________________________ Digital Learning Network

Date ______________________________

Unscramble the words below:

1. YEGREN_________________
2. TEHA FSNTARER _______________
3. HWTGANVEEL_________________
4. AROLS LELC_________________
5. GTILH TRECSMPU______________
6. SATSM_________________
7. YRSARA_________________
8. UTITDATE_________________
9. SMTAOCEIRHP_________________
10. TPOVICALOHOT______________
11. AROLS YEGREN _______________
12. ACENDGIU_________________
13. VAGINOTINA_________________
14. CPYOOGERS_________________
15. CELAUNR_________________
16. SNSOIIF_________________
17. EIICKNT_________________
18. TABERYT_________________
19. WEOPR_________________
20. LNTTAIEOP_________________
21. ISUOFN_________________
22. MTOA_________________
23. LNCUUSE_________________
24. EOURTNN_________________
25. IHANC TRACEOIN______________

Energy Vocabulary Word Scramble

Answers

1. **YEGREN is Energy**
2. **TEHA FSNTARER is Heat Transfer**
3. **HWTGANVEEL is Wavelength**
4. **AROLS LELC is Solar Cell**
5. **GTILH TRECSMPU is Light Spectrum**
6. **SATSM is Masts**
7. **YRSARA is Arrays**
8. **UTITDATE is Attitude**
9. **SMTAOCEIRHP is Atmospheric**
10. **TPOVICALOHOT is Photovoltaic**
11. **AROLS YEGREN is Solar Energy**
12. **ACENDGIU is Guidance**
13. **VAGINOTINA is Navigation**
14. **CPYOOGERS is Gyroscope**
15. **CELAUNR is Nuclear**
16. **SNSOIIF is Fission**
17. **EIICKNT is Kinetic**
18. **TABERYT is Battery**
19. **WEOPR is Power**
20. **LNTTAIEOP is Potential**
21. **ISUOFN is Fusion**
22. **MTOA is Atom**
23. **LNCUUSE is Nucleus**
24. **EOURTNN is Neutron**
25. **IHANC TRACEOIN is Chain Reaction**

Resources

NASA Kids
For activities, games, stories and more, visit this website specifically designed for kids that are interested in space and NASA.
http://www.nasa.gov/audience/forkids/home/index.html

Background Information

For other activities on Energy for Grades 5-8 visit:

The Sun is Cookin'
How to use solar energy to cook a hot dog.
http://dln.nasa.gov/dln/admin/media/download.jsp?file_id=1254

Keeping Your Plane Lit
How to measure the spread of light from a flashlight.
http://dln.nasa.gov/dln/admin/media/download.jsp?file_id=1255

Contributors and Developers

Rene Flores	**Johnson Space Center**
Michelle Leggett	**Johnson Space Center**
Erin McKinley	**Johnson Space Center**
Michael Ewert	**Johnson Space Center**

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